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Optimal Control in Manufacturing Areas Increase the Productivity in the Aerospace Industry of Mexicali, Baja California, México

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Abstract: The efficient control in the manufacturing control is very essential to increase the productivity and some specialized devices are made with and adequate functions. These devices are MEMS (Micro Electromechanical Systems), which are low-power microdevices widely used in the industrial processes of the Mexicali aerospace industry, which have the function of controlling the operation of industrial systems at any stage of manufacturing by evaluating the way to carry out their activities, comparing standardized values with data real and activate and deactivate high power actuator mechanisms such as fans, motors, electric pumps and other high power used in this installed industry. These microdevices have specific characteristics in their operation to obtain the best operational performance of industrial equipment and machines, at a low cost and partially operating according to the operating system reference values of industrial systems and generating a safe process in their operation. The industrial processes of the Mexicali aerospace industry require specialized knowledge because they manufacture components with very rigid operations because they are manufactured for aircraft with very rigorous regulations, due to the high security that air transport requires. MEMS have increased their use in the last ten years, where it has been applied to various industries due to the simple way of coupling with industrial systems, and this is why research was conducted to evaluate its use in a company in this city that they did not intend to use them and when observing that they increased their productive performance at one stage of their industrial processes, they chose to apply them in all their manufacturing areas. The investigation was from 2018 to 2019.

Keywords: MEMS, productive performance, aerospace industry, industrial manufacturing.

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I. INTRODUCTION

MEMS have revolutionized technology in the aerospace industry by being used as control systems in manufacturing areas, with microlevel electromechanical systems coupled with industrial processes to control high power industrial equipment and machinery[1]. These microsystems made activities of installation and gluing of electronic components in electronic boards used for the operation of the autopilot in the evaluated industry. In addition to these functions, MEMS can verify standardized reference values and compare them with real data, to check that the operation of manufactured products operate efficiently, elaborating the shutdown activity to stop equipment operations and industrial machinery when it is required to verify in detail any situation outside the functional characteristics of the manufactured articles[2]. Likewise, MEMS can perform the ignition function to continue monitoring production. Figure 1 shows illustrations of MEMS, observing in 1A a microconnection and 1B several electronic micro-racks where MEMS are installed and connected. Figure 1 represents a 10 micron view of a microconnection and electronic microdrives of a MEMS used in a stage of a production line in the aerospace industry analyzed, observing that Figure 1A illustrates two sections of electrical connection in good condition, indicating that the micro system is working optimally and in figure 1B, several electronic boards are shown (segmented by squares), showing in the central part of each box the connection place for two MEMS. This microanalysis was developed to adequately know the operability of the microsystems and to evaluate the productivity and determine if it was necessary to elaborate any adjustment in the micro-connections of the MEMS or in the microtableros and quickly make the required modifications. It is noted that the tuning process with the microsystems was developed in a company that develops specialized microscope electronic microcircuits[3].

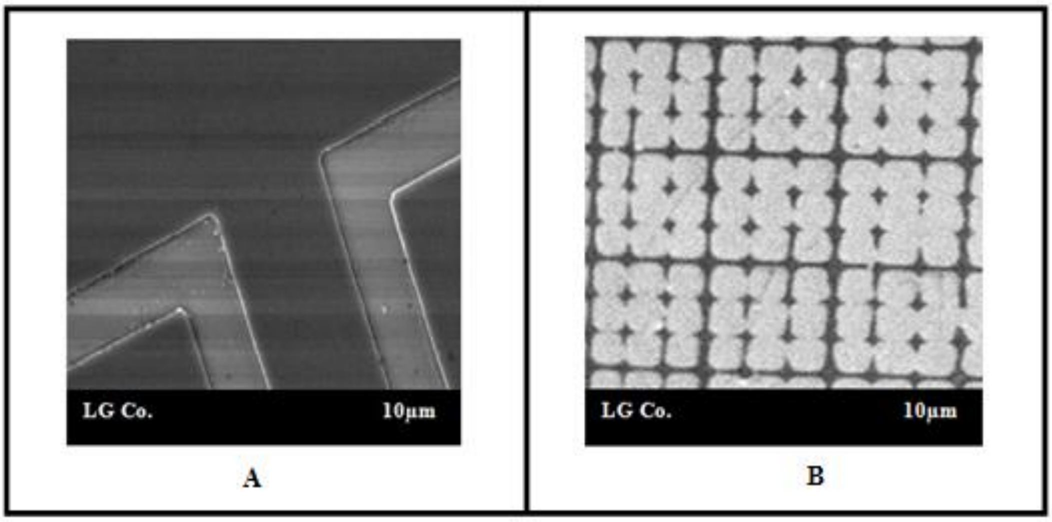

Fig. 1. Microscopic view of MEMS: (A) Microconexions and (B) Electronic microboards to MEMS (10X)

Importance of using MEMS

MEMS technology has been a very relevant topic since the beginning of the 21st century to optimize activities in the manufacturing areas, being very useful for controlling various operations, where every day the industries have the objective of improving the efficiency of manufactured products and industrial processes, having these micro systems in small spaces and reducing the sizes of equipment and industrial machinery[4]. With MEMS they are applied in all types of industries and in aerospace it is no exception, where they are used in various systems The investigation made in an aerospace industry was an analysis of the use of these micro systems to improve the operability of equipment and machinery industrial and quickly and effectively evaluate the main operating characteristics of manufactured products, being evaluated with electronic transmission-reception sensors, optical and electrical and electromechanical. The study elaborated was relevant in modern society because it improves the interaction between the manufacturer and the consumer, which ensures the reliability of manufactured products, generating benefits for the manufacturer and the customer[5].

Origin of electromechanical microsystems

The main objective of MEMS manufacturing was to evolve technologies that sought to miniaturize simple and complex industrial systems and that operated in smaller areas, saving space in industries by having small and not large buildings that generated higher construction or rental costs. to reduce operating costs. MEMS integrate multiple functions in a microelectronic device[6]. The term MEMS was developed in the United States at the beginning of the 21st century and in Europe it became known as micro technological systems (MST), and today MEMS has become increasingly prevalent throughout the world with this terminology. Experts on this topic agree that MEMS had its beginning when developing semiconductors, based on the manufacture of transistor in Bell laboratories, developed by scientists Shockley, Bardeen and Brattain in 1947. This evolved the technology of that time in especially the area of electronics to create devices with greater capacity, speed and operational functionality, smaller and at lower cost, accelerating technological development in the 21st century[7]. At the beginning, it was difficult to connect the electronic microcomponents because the reduced space caused their microconnections to be very close and joined at the time of manufacture, so it caused short circuit and interference between them when operating.

MEMS operational efficiency

The development of these microsystems has revolutionized the technology of electronics, only it has had its limitations with respect to its application due to a lack of knowledge and willingness to be used by the management and supervisory personnel of the various types of industries, in addition of not having the manufacturing and testing technology, which generates a higher cost when requesting them from the MEMS developers with the required specifications[8]. There are some industries worldwide, which have in their facilities the way to manufacture them and specialized personnel for the preparation of tests and support when used in their industrial processes, being innovative companies that have had great growth in a short time due to use MEMS as control microdevices[9]. The first electromechanical microsystems were developed for microsensors, generating the great discovery of piezoelectricity activity, obtained from the union of silicon with germanium to manufacture the pressure sensor, being a novelty at the time of its manufacture and currently with great variety of functions in industries and other activities. In addition to using silicon, the scientists who created MEMS began to develop other experiments with other types of materials to be applied not only to products manufactured in the electronic industry, but in other industries such as aerospace, agriculture, food and beverages, automotive, biomedical, ceramics, metalworking, plastics, telecommunications and textiles[10, 11].

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Evolution of MEMS

After the MEMS were created a little before 1950 with experiments made mainly with silicon material and the creation of the piezoresistive micro sensor in 1953 and semiconductor strain gauges in 1957, the development of other microdevices was accelerated as solid state microtransducers and micro-actuators for strategic functions in various industries[12]. Once the operation of the piezoresistive sensor was understood, the pressure sensor was manufactured in the 1960s, which is widely used today; microtransducers after 1970, micro-actuators in the 1980s, micro-mechanisms and micromotors between 1987 and 1989, and from that date to the present day the creation of microsystems, leading to the development of MEMS with the manufacture of micro-robot micromachines[13,14]. All the technology developed after 1970, was due to the operation of microtransducers and micro-actuators and it was in 1987 when the term MEMS was created after three meetings, one held in Salt Lake, Utah, another in Hyannis, Massachusetts and the last one in Princeton, New Jersey, so that academics and experts on the subject named it with this term, being pioneers in this type of technology. Currently MEMS are used in used as an interdisciplinary factor of knowledge used in countless areas of science and engineering, for the solution of problematic situations, largely linked to control engineering[15].

Manufacturing Features

The manufacture of MEMS requires three important stages for its optimal functionality, each one being explained immediately[15].
a) Miniaturization. The goal is to make very small devices on a microscopic scale with very short response times.
b) Multiplicity. It generates very efficient operations to manufacture a large quantity of articles in a short time.
c) Microelectronics. It consists of coupling specialized electronic components in an optimal way to efficiently carry out industrial operations.

These characteristics determine the way of operating the MEMS based on the required needs, being of great relevance in the manufacturing areas of the aerospace industry. One of the important aspects is that not all electronic components, even miniaturized, can be coupled due to their operating specifications.

Control systems

They are devices and equipment that have the ability to manipulate actions of activities in manufacturing areas. It is composed of several elements that interact with each other to perform the appropriate functions in industrial operations, with the aim of obtaining a desired result. They exist of open, isolated and closed type and with feedback[5]. The control systems operate based on certain regulations, obtaining numerical information of the evaluated variables and preparing the necessary control with a comparative process of standardized values. These systems control actuators, generating activation and deactivation functions at the indicated times for optimal operation of industrial equipment and machinery[16]. Control systems in electronic devices can be simple or complex, depending on what you want to manipulate, to be evaluated based on their functionality, designed and manufactured with basic components such as coils, capacitors, relays, resistors and low-power transistors that control high power actuators that generate high effort activities required in the analyzed production line. This activity gives great support to the manufacturing areas generating great savings.

1.8 Innovations with MEMS

MEMS have been the devices that have generated great importance in the last ten years, which is why many industries have decided to use them in a great many industrial processes. In addition, educational institutions have chosen to teach topics related to electromechanical microsystems, preparing experimental tests for application in various areas of engineering. This is done to control having a constant inspection of features or activities that equipment cannot control[17, 18].

II. METHODOLOGY

An investigation in an aerospace industry in the city of Mexicali, with four steps was made to improve the control of certain steps in the manufacturing areas. The steps developed are explained below:

Step 1. A correlation analysis of operative efficacy and operability and workers, e yielding of industrial equipment and machinery and workers, in a production line 1 of the automatic and manual insertion area of an aerospace industry installed in Mexicali, where electronic micro-drums used in the autopilot system of commercial aircrafts are manufactured.

Step 2. A correlation analysis of productivity and quality was made to evaluate the situations in the initial time without use MEMS and after utilized MEMS, obtained comparative evaluations.

Step 3. Was made a mathematical simulation with the Simulink of MatLab[17] used to design MEMS developed to control the operation of an industrial machine for surface installation and assembly of electronic microcomponents, to control activation and deactivation times to support savings in energy consumption and expenses production.

Step 4. Once the optimal operation of the MEMS of the previous step had been determined, two MEMS were created, being for a functional characteristics review team analyzing current and voltage values of the autopilot devices and comparing them with standards reference.

The use of MEMS in the industrial processes of any type of industry is of great importance because it has greatly helped to increase the production, quality and productivity indices. Based on this, statistical evaluations are made with the MatLab program[18].

III. RESULTS

The evaluations prepared reflected the conditions in which the industrial process operated, where the goals proposed by the management area were not achieved. This occurred due to the lack of control when not using the MEMS.

Once the electromechanical microsystems began to be used, both the industrial equipment and machinery and the workers increased the operating levels, and with this the productivity indices that kept the management and supervisory personnel concerned.

Correlation of operability and operational efficiency

The operability of the industrial equipment and machinery together with that of the workers is an adequate indicator that reflects the way in which the activities in the evaluated aerospace industry were carried out. Before using the electromechanical microsystems, there was not a total control of all the stages in the industrial processes, so that in some areas of the manufacturing areas, unfinished products were observed, generating incomplete inventories and with it unnecessary storage costs. Figures 2 and 3 show a correlation of indices of the operating efficiency of industrial equipment and machinery and of workers, being an important factor in achieving the proposed goals in various hourly, daily, weekly, monthly, seasonal and annual periods. In figure 2 belonging to the month of June 2018, the number of workers that it was necessary to require to prepare manual operations that later with the use of MEMS is observed, being 90 people in line 1 that was evaluated in this investigation, where a large part of these personnel sometimes did not carry out any activity because the management and supervision personnel commented that this amount was necessary as an emergency worker to replace some workers when they felt tired or were not in adequate conditions to carry out their functions in a manner Optimal for the health aspect or for some other situation that complicates the operational performance of the workers. Regarding the quantity of equipment and machinery it was 10 as a whole and in operational efficiency, indices are presented with a maximum of 60%, indicating that there were not optimal productivity indices, as they did not have a good use of the equipment and industrial machinery and workers of line 1 analyzed.

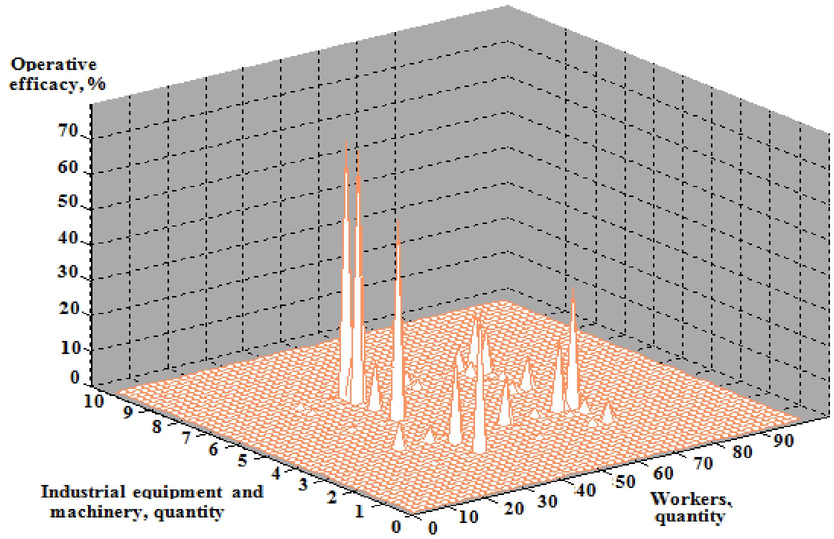

Fig. 2. Correlation of indices of operational efficiency and operational performance of industrial equipment and machinery and workers (June 2018)

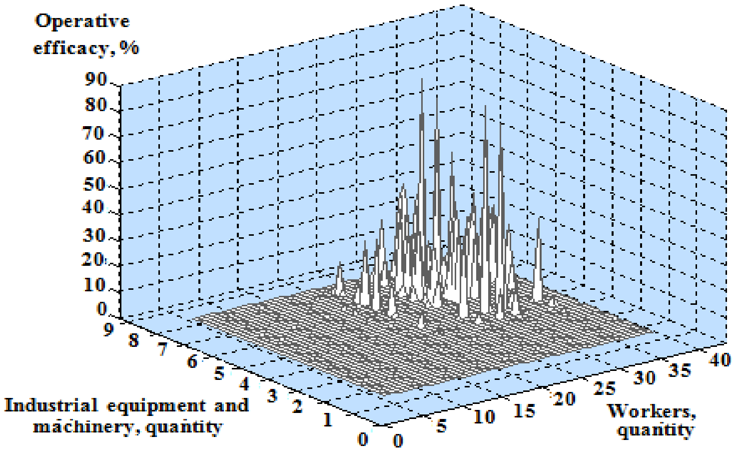

Fig. 3. Correlation of indices of operational efficiency and operational performance of industrial equipment and machinery and workers (June 2019)

After evaluating the situation of the evaluated manufacturing area, it was determined to use the electromechanical microsystems to improve productivity levels as represented in Figure 3, indicating that it is from the month of June 2019. The evaluations were in the months of June that It is when this aerospace industry had its maximum operational performance in both industrial equipment and machinery and in workers. This figure shows that the number of workers decreased to 40, relocating the rest of the 90s and generating savings in production costs. This occurred. MEMS developed industrial operations control processes, reducing the workforce and increasing automation activities. The relocated workers developed functions in a new production line, which was necessary to start operations of a new product, increasing the competitiveness of the evaluated industry. The amount of equipment and machinery was reduced from 10 to 9, saving on electricity consumption and operating efficiency increased to nearly 80%.

Productivity and quality correlation

Figures 4 and 5 illustrate the productivity indices, indicating levels of up to about 75% for the month of June 2018, production levels close to 6,000 products manufactured in this analyzed month and quality indices close to 50% . This is because there were various manual activities that generated a large number of errors, decreasing production levels. This was due to the lack of control at each stage in an optimal way, being a situation that concerned management and supervisory personnel, which required an investigation supported by expert investigators

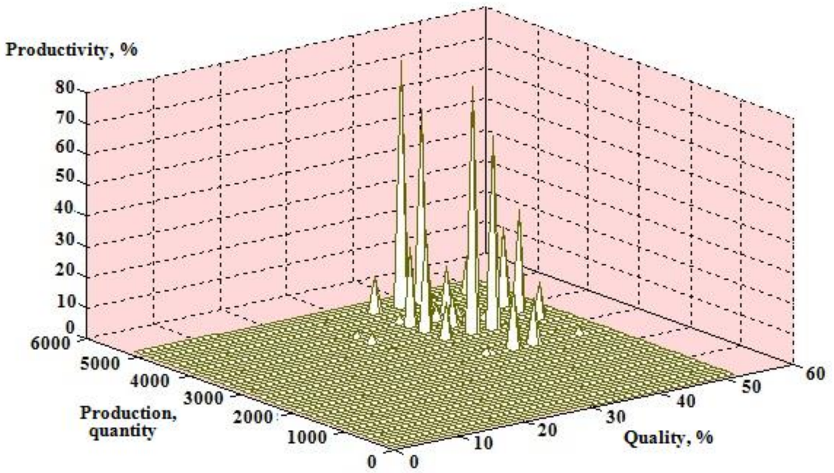

Fig. 4. Correlation of productivity and quality levels (June 2018).

In a large majority of industries of any type, managers and supervisors of industrial processes at each stage of manufacturing areas focus on the main production activities, and the concentration is so high that they do not generate improvements and continue to eject operations as a customary process, even observing that there were human and industrial equipment and machinery errors. In addition, they learned that unfinished products were stored due to the generation of errors, causing extra production costs. Figure 5 illustrates productivity levels close to 80%, increasing this factor by 5%, in addition to quantities of manufactured products close to 9000 and with quality indices of 85%.

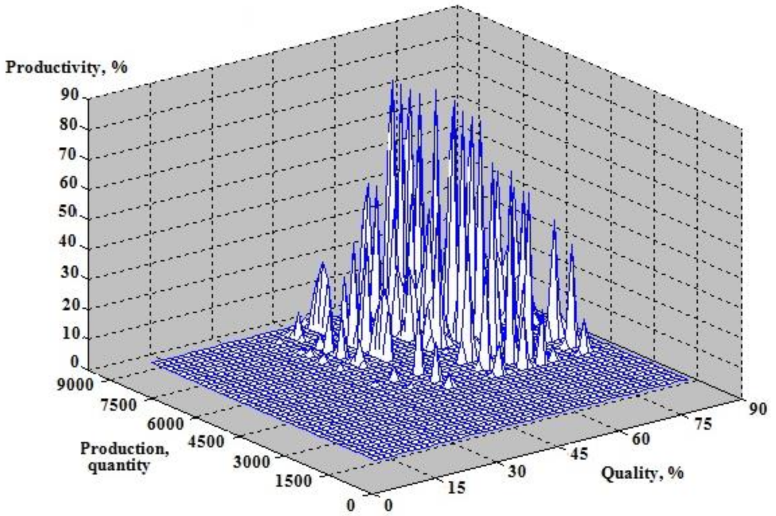

Fig. 5. Correlation of productivity and quality levels (June 2019).

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Microanalysis of MEMS connections

One of the important aspects to achieve the optimal functionality of the MEMS was the microclimate control, with which these microsystems that developed the functions of control of industrial operations could be kept operating in good condition. In figure 6, a micro-micron analysis is shown, where small dust spots are observed, without being relevant to the functionality of MEMS. By other way, was necessary have micro-connections as clean as possible without the presence of agents that disturb their operation was due, in particular, to the industry being evaluated. I implement the placement of specialized filters to avoid the presence of contaminating agents, as well as dust or microorganisms, in addition to temperature and relative humidity control. . The lifetime estimate with optimal MEMS functionality was five years, without generating failures. The period of this microanalysis was one year.

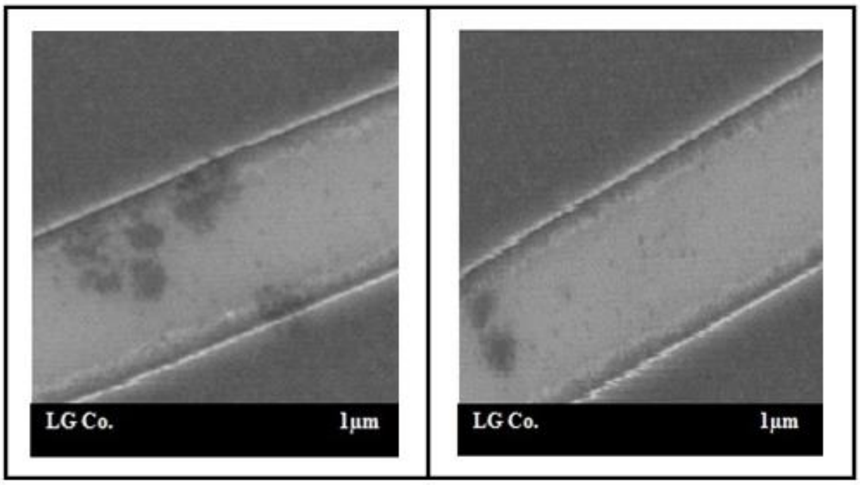

Fig. 6. MEMS microconnections dirty by dust from the interior of the evaluated industry

IV. CONCLUSIONS

The use of MEMS has generated expectations for the development of new technologies and innovation, increasing productivity, quality, and improving the operational efficiency of industrial equipment and machinery and of workers in manufacturing areas. These microsystems have supported the solution of problematic situations in various applications, where they have contributed to improving the living conditions of the populations, in addition to security aspects, such as the case of this research with the manufacture of electronic microsystems controlled by MEMS for the automatic pilot of a commercial aircraft. In addition, in the area of medicine, they have helped save lives with electromechanical microsystems implanted in the body or ingested to solve a health symptom. MEMS technology has created new opportunities in industries, being a great example of a solution from a different perspective, offering safer, more efficient and economic solutions, with reduced spaces and the development of new industrial processes and products. This investigation was made in an aerospace industry in the city of Mexicali, was very relevant, observing that the productivity, quality, operability and safety indices were increased in the industrial processes evaluated in order to replicate the study throughout the company in all manufacturing areas.

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